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CARTOGRAPHIC DATA RETRIEVAL, ANALYSIS, DEPICTION, PRESENTATION AND PRODUCT GENERATION: DIGITAL DATA BASES

Digital cartographic data products and activities of the United States geological survey

Paper submitted by the United States of America**

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The U.S. Geological Survey is the prime source of many kinds of digital cartographic data of the United States and its outlying areas. These data include (1) Digital Line Graph data, which contain information about boundaries, hydrography, hypsography, transportation, and other features found on the Geological Survey's topographic maps; (2) Digital Elevation Model data, which contain the elevations of a regular array of point observations; (3) land use and land cover data, which contain information about land use and cover patterns and other associated layers of information; and (4) geographic names data. The Geological Survey also coordinates the development of standards for digital cartographic data, conducts research in the areas of geographic information systems and related technologies, and distributes digital cartographic and other earth science data to users.

Introduction

The U.S. Geological Survey is a source of many kinds of topographic and special-purpose maps of the United States and its outlying areas. It is also a source of digital map data.

Many public agencies, private organizations, and individuals need reliable cartographic and geographic knowledge about the Nation. To serve such needs, Geological Survey maps are compiled to exacting standards of accuracy and content.

Today, an ever greater extent of the Nation's landscape is being translated into digital map data. These data are collected from Geological Survey topographic maps or acquired from satellite or other non-photographic sensors. Such data help to create and update a comprehensive set of line, image, and thematic maps. The data can be analyzed to find answers to a host of cartographic and geographic questions.

Digital Cartographic Data Products

Needs are growing rapidly for digital cartographic data to support mapmaking and geographic information systems. Moreover, sound Earth and water resources management now calls for computer-compatible cartographic and special-purpose data to provide a basis for analysis.

The Geological Survey produces digital cartographic data and distributes them through the National Digital Cartographic Data Base (NDCDB). The NDCDB includes:

- topographic line map data as Digital Line Graphs (DLG's),
- elevation data as Digital Elevation Models (DEM's), and
- land use and land cover data.

In addition, the Geographic Names Information System contains digital descriptions of places, features, and areas in the United States identified by proper names.

Digital Line Graph (DLG) Data

DLG's are vector files of cartographic data made primarily by digitizing point locations, lines, and polygon outlines from map-separation materials. They are prepared from primary series (ranging in scales from 1:20,000 to 1:63,360) and from 1:100,000- and 1:2,000,000-scale source maps.

These data are a framework of reference for other data about the Earth and its natural resources. These data are useful for computer-assisted production of cartographic products. They are organized to support the analytical functions of geographic information systems.

The spatial data are topologically structured. Spatial relationships, such as adjacency and connectivity among data elements, are explicitly encoded.

In addition, DLG data elements may have coded attributes. These feature codes identify the major category, such as hydrography, to which a data element belongs and add other specific feature information, such as "shoreline" or "spring" or descriptions and parameters, such as "intermittent" or elevation of the water surface.

Work in progress includes the conversion of boundary, contour, hydrography, transportation, U.S. Public Land Survey System (PLSS), and other selected data to digital form.

DLG data derived from primary series topographic line maps are available for portions of all 50 States and Puerto Rico. For the 48 contiguous States and Hawaii, digitizing of boundaries is 25 percent complete; contours, 1 percent; hydrography, 6 percent; transportation, 5 percent; and PLSS, 26 percent. Coverage is available for approximately 2 percent of Alaska for each category. Most of the DLG data are distributed as 7.5-minute cells.

Transportation and hydrographic data were digitized from 1:100,000-scale quadrangle maps to meet the Bureau of the Census's needs for base map information for the 1990 Census. Coverage is available for all the 48 contiguous States and Hawaii. Boundary, PLSS, and contour data are being collected. These data are distributed in 30-minute blocks.

Boundary, hydrography, and transportation data were digitized from revised 1:2,000,000-scale sectional reference maps from the National Atlas of the United States of America. Coverage of the 50 States is available in 21 regional sections.

An improved data model, called Digital Line Graph-Enhanced (DLG-E), will soon be in use. DLG-E provides for the explicit representation of individual cartographic features, such as roads, counties, buildings, and streams, in addition to the topologically structured spatial data provided in the current DLG. This enhancement also provides a more extensive set of attributes and relationships for these features than exists in a DLG.

Digital Elevation Model (DEM) Data

DEM's are arrays of elevation data, usually at regular intervals. DEM's can be used to generate simulated views of a landscape; to calculate capacities of reservoirs and volumes of lava flows; to assess terrain in relation to other environmental factors; to predict brush and forest fire behavior; and to calculate slope for such applications as hydrologic process modeling to gauge the effect of precipitation on ground-water and surface-water runoff.

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The Geological Survey produces DEM's by computing elevations from digitized vector contour data, by scanning stereomodels produced from aerial photographs, or by resampling higher-resolution DEM's.

For DEM's corresponding in coverage to 7.5-minute topographic quadrangle maps, elevations are processed to produce data at 30-meter ground spacing with the Universal Transverse Mercator coordinate system as a framework. For Alaska, the DEM's corresponding in coverage to 15-minute topographic quadrangle maps are processed to produce data at 3-arc-seconds of longitude by 2-arc-seconds of latitude spacing. Coverage is available for 35 percent of the 48 contiguous States and Hawaii, and for approximately 8 percent of Alaska.

Recently, the Geological Survey began producing DEM's from 1:100,000-scale DLG contour data or from resampled 7.5-minute DEM's. These data are processed to produce data at 2-arc-second spacing, and are distributed in 30-minute blocks.

The Geological Survey also distributes DEM's produced from digital terrain elevation data collected by the Defense Mapping Agency from 1:250,000-scale maps. Elevations are interpolated every 3 arc-seconds of longitude and latitude, except in Alaska, where spacing varies. These DEM's are distributed in 1-degree cells. The 3-arc-second DEM's consist of more than 1.4 million elevation values. Coverage is available for all the 48 contiguous States and Hawaii, and most of Alaska and Puerto Rico.

Land Use and Land Cover Data

For the 48 contiguous States and Hawaii, land use and land cover data are made by digitizing land use polygon outlines from 1:250,000- and 1:100,000-scale source maps.

Work in progress includes digitizing land use and land cover data and associated map data, including hydrologic units, political units, and census county subdivisions. Federal and State land ownership has been digitized in selected areas.

These data are available in vector and raster forms. The vector data, encoded in the Geographic Information Retrieval and Analysis System (GIRAS) format, are topologically structured. The raster data, encoded in the Composite Theme Grid (CTG) format, are composed of an array of cells. Each cell is completely identified with attribute codes for all land use and land cover and associated map data.

Digital data are available for more than 80 percent of the 48 contiguous States and Hawaii. Completion is scheduled for 1992.

For Alaska, land cover data are generated using Landsat multispectral scanner digital data. These raster data are encoded in a format different from the CTG format described above. Approximate 2 percent of the coverage planned for Alaska is available.

Geographic Names Data

Information about places, features, and areas in the United States identified by proper names and geographic locations is distributed through the Geographic Names Information System. This national data base contains about 2 million entries; when completed between 1998 and 2002, it will hold about 5 million entries. The Geographic Names Information System is the Federal government's official source of geographic names as sanctioned by the U.S. Board on Geographic Names.

Coordination of Data Standards

The Geological Survey is also active in coordinating matters related to Federal digital cartographic data.

In 1980, the National Institute for Standards and Technology agreed to assign to the Geological Survey leadership in defining and maintaining Federal earth science standards.

Under this agreement, the Geological Survey is coordinating the development of a standard for the exchange of digital cartographic data, called the Spatial Data Transfer Standard. This Standard was developed through grants to the National Committee for Digital Cartographic Data Standards, which functioned under the auspices of the American Congress on Surveying and Mapping. The Federal Interagency Coordinating Committee on Digital Cartography also contributed to the development of the Standard.

The need to transfer spatial data between different systems is becoming increasingly important. The concern for common data formats and coding conventions cuts across all aspects of cartographic data handling. Users find it difficult and inefficient to use data because of differences in underlying concepts, terminology, and formats.

The proposed Spatial Data Transfer Standard provides a national standard for the exchange of digital spatial data. The standard includes definitions of terminology, a transfer specification, recommendations on reporting data quality, and terms and definitions of features commonly found on topographic maps and hydrographic charts. The Federal government, the private sector, and the academic community have been working for several years to develop this proposed standard.

Empirical testing of the Spatial Data Transfer Standard was completed in 1989. Improvements have been made to the Standard based on the test participants' suggestions. The Standard will be submitted to the National Institute for Standards and Technology in mid-1990 for designation as a Federal Information Processing Standard.

Geographic Information System Facilities and Research

Spatial analysis is an emerging discipline being applied to geographic information systems at the Geological Survey. Over 500 Geological Survey scientists and engineers have received formal training in geographic information system technology. Geographic information system applications software is available on a nationwide network consisting of approximately 85 minicomputers, a mainframe computer, plus additional stand-alone microcomputer and workstation systems. Within the Geological Survey (and in more than 100 cooperative application and demonstration projects with other Federal and State agencies), geographic information system technology has been applied in fields as diverse as water quality, geologic mapping, minerals exploration, oil and gas development, earthquake and other natural hazards analysis, forest management, public health, environmental analysis, wildlife management, agriculture, soils mapping, urban planning, and the 1990 Census.

The Geological Survey operates 3 interdisciplinary geographic information system research laboratories located in Virginia, Colorado, and California to support cooperative applications development and to facilitate evaluation of advanced geographic information system technologies. Long-term research is designed to address land surface characterization for global change and other dynamic, time-dependent, process modeling activities. The Geological Survey's EROS Data Center in Sioux Falls, South Dakota, will serve as the national archive and data manager for land surface data for global change research.

Earth Science Information and Sales

The Geological Survey's Earth Science Information Centers (ESIC's) offer nationwide information on earth science data holdings and sales service for Geological Survey map products and earth science publications. This network of ESIC's provides information about geologic, hydrologic, topographic, and land use maps, books, and reports; aerial, satellite, and radar images and related products; earth science and map data in digital form and related applications software; and geodetic data.